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DISEASES of RICE

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The principal and minor diseases of rice and their effect on stands, yields, and quality are briefly described in the following pages, with suggested methods of control.

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Cover illustration.—Lodging caused by stem rot in a field of Blue Rose rice in the vicinity of Almyra, Ark.

DISEASES OF RICE[1]

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INTRODUCTION

RICE was grown in the South Atlantic States for a period of nearly 200 years before any serious disease was reported. About 1905 diseases were found following the development of the rice industry in southeastern Arkansas. In 1906 blast threatened the crop in South Carolina, and a study of this disease was begun. At present the most serious diseases of rice in the United States are seedling blight, leaf and leaf-sheath spots, leaf smut, stem rot, kernel spots, kernel smut, straighthead, and white tip. These diseases occur also in other rice-growing countries of the world.

Most of the diseases that affect the growing crop probably came into the United States on seed introduced from foreign countries prior to the establishment of the plant-quarantine laws. Fifty-two species of organisms (fungi) have been found on rice plants in this country, but some are not known to cause disease. Although most rice diseases are caused by fungi, some are caused by unfavorable soil or weather conditions or by small worms (nematodes).

Fungi are moldlike plants, such as those that develop on stale bread, that grow in the soil or in plant tissues. Many of them are able to live on dead plants during the periods of the year when there are no live plants on which they can grow. Some produce spores or other structures (sclerotia), more or less comparable with the seeds of higher plants, to carry them over adverse periods of cold or dry weather. These are the means by which the diseases are spread from one plant to another.

The cause, symptoms, and means of control of the more important rice diseases are discussed in the following pages. The arrangement of

[1] Cooperative investigations of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Arkansas, Louisiana, and Texas Agricultural Experiment Stations.

the diseases is as nearly seasonal as possible; that is, the seedling diseases are discussed first, then leaf and sheath spots, followed by stem rots and kernel diseases.

SEEDLING BLIGHT

Seedling blight of two types occurs on rice in the Gulf States area. In one type apparently healthy seedlings are attacked at the ground line by a fungus [2] that produces an abundant white growth (mycelium) over the surface of the soil and on the lower part of the plant. This disease is most common during periods of moist, warm weather after the rice seedlings emerge and before irrigation. The affected seedlings are discolored slightly, and a whitish cottony growth of the fungus appears at the soil surface. Later, small, round, light-brown seedlike fungus bodies may be found on the lower parts of the seedlings. Many severely affected seedlings are killed by the disease, and stands are thus reduced. Immediate submergence of the land checks the development of the disease and gives the less severely attacked seedlings a chance to recover and develop into normal plants.

Seedling blight may also be caused by other fungi.[3] Many of the seedlings that are attacked by these fungi fail to emerge from the soil during cool, damp weather, and marked reduction in stands may occur.

Experiments indicate that the use of some of the commercial dusts [4] for treating the seed before sowing provides considerable protection for the seedlings and helps to get increased stands, particularly of early-sown seed. This factor of protection is especially valuable in Louisiana and Texas where seeding frequently is begun in the latter part of February and early March. Cold rainy weather may so retard germination that if the seedlings are not protected stands are lost. Treatment is most effectively applied at the time the seed is cleaned and sacked. Methyl bromide also is effective for control of seed-borne fungi. See information on dosage and exposures under discussion of white tip.

***Caution.*—The chemicals mentioned in the seed treatments are injurious to man and animals when taken internally. Therefore, care should be used in handling them to prevent their contact with the mouth, eyes, or nostrils. When these chemicals are used in dust form, care should be taken not to inhale them.**

ROOT KNOT

Root knot is caused by a kind of minute worm known as a nematode,[5] which also attacks many other plants. It was found on rice roots in one field in Arkansas in 1933 and has also been found there

[2] *Sclerotium rolfsii* Sacc.

[3] *Helminthosporium oryzae* van Breda de Haan, *Curvularia lunata* (Wakker) Boedijn, and *Trichoconis caudata* (Ap. & Str.) Clem.

[4] The dusts that have proved most effective in recent years are sold under the trade names of Cuprocide, Arasan, Ceresan M, and Dow 9B. These are used in slurry form with Cuprocide, Arasan, and Dow 9B at the rate of 1 ounce per bushel, or 3.6 ounces per barrel, and Ceresan M at 0.5 ounce per bushel, or 1.8 ounces per barrel of 162 pounds.

[5] *Heterodera marioni* (Cornu) Goodey.

since. The infected parts of the roots of the seedlings become much enlarged and deformed, and stop growing (fig. 1). The above-ground parts of affected plants become somewhat dwarfed, turn yellow, and many of them die. This disease of rice is of minor importance.

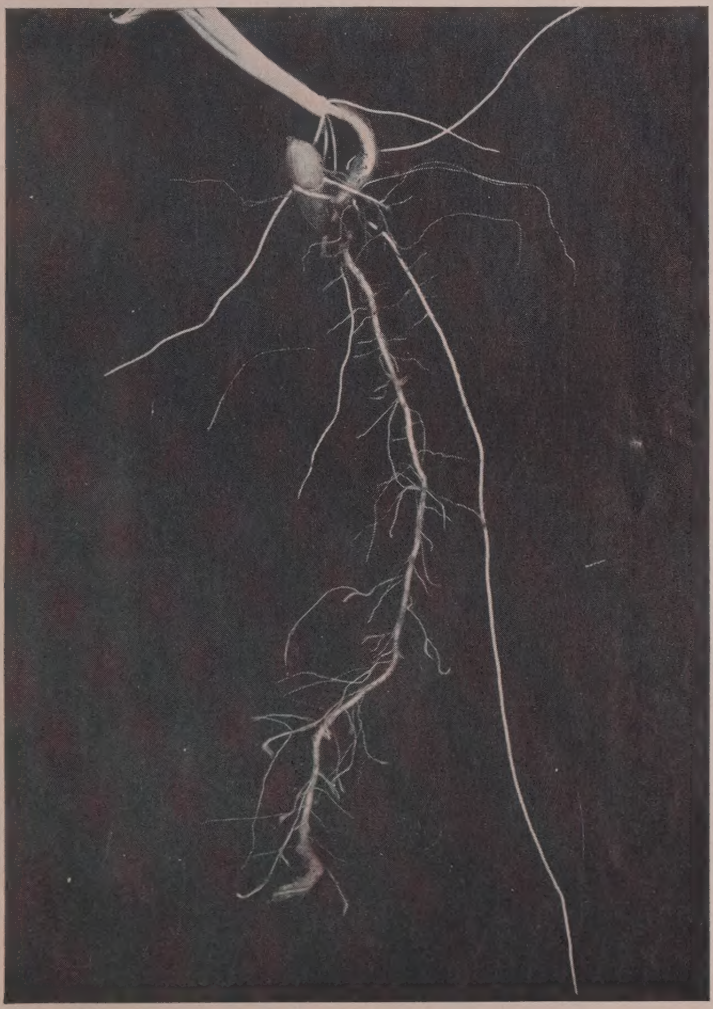

Figure 1.—Root knot of rice. Twice natural size.

WHITE TIP

White tip [6] is characterized by the production of colorless leaf tips. The leaf tips, and occasionally other parts of the leaves or panicles,

[6] Caused by the nematode *Aphalenchoides oryzae* Yakoo or a similar nematode described from India.

are lacking in green color when they emerge from the sheath or boot. These symptoms are produced by the feeding of the parasitic nematodes that have attacked the tissues of the leaf or panicle head while it was still enveloped (protected) by the sheath or boot.

The nematodes establish themselves inside the flowers, and after the seed is formed they remain there in a dormant condition until the seed is planted. With increase in moisture and growing tissues on which to feed, the nematodes become active, feed on the developing seedling, and rapidly increase in numbers. In extreme cases, the feeding is so extensive that the plant fails to produce a panicle (head). This no doubt results from injury of the growing point of the shoot.

This nematode probably was introduced into the United States on seed from India or Japan.

White tip symptoms appear from June to August, when the rice plants are from 2 to 3 months old. Blue Rose rice affected by white tip is shown in figure 2. The whitening of ½ to 1½ inches of the leaf

Figure 2.—White tip of Blue Rose rice (at left) at Rice Experiment Station, Crowley, La. The variety to the right of the arrow is not affected.

tips is observed first, but the whitening often spreads farther on such leaves as the plant becomes older. The areas affected turn white or greenish white and are of a papery texture. Affected leaves are shown in figure 3. This type of injury also produces sheath twisting, which results in imperfect emergence of the head and deformed grain. In severe cases the plants are dwarfed and the panicle (head) may not be formed.

Most commercial varieties appear to be susceptible, but most of the long-grain varieties are free from typical white tip symptoms. Control of the seed-borne phase without injury to germination may be

Figure 3.—A, White tip; *B* and *C*, absence of green color at the base and middle of Blue Rose rice leaves, caused by this disease.

secured by fumigation with methyl bromide at the rate of 1¼ pounds per 1,000 cubic feet for 12 hours. Seed should be at about 13-percent moisture when fumigated.

Methyl bromide is a poisonous gas and the detailed precautions furnished with the material should be closely observed.

LEAF SPOTS

BROWN SPOT

Brown spot is one of the most serious fungus [7] diseases of rice in the southern United States. It also occurs in Japan, Cochinchina, China, Indonesia (Dutch East Indies), the Philippines, Peru, Colombia, Italy, and India. The disease is found in Louisiana and Texas and to a lesser extent in Arkansas. It attacks the seedlings, leaves, "necks," hulls (glumes), and kernels of rice. It may attack the seedlings and cause seedling blight at any time until the seedlings attain a height of about 4 inches. Brownish discolorations first appear on the sheaths between the germinated seed and the surface of the soil or on the roots. Badly affected seedlings die because their upper parts are cut off from the roots by the girdling action of the fungus, and stands of rice are thus reduced.

On the leaves the spots are circular to elongate and usually are most abundant in August and September. The small spots are dark reddish brown, and the larger ones have dark reddish-brown margins and grayish centers (fig. 4). On severely affected plants the leaves

Figure 4.—A, Brown spot on leaf of rice from natural infection in the field. Twice natural size. *B,* Brown spot on the hulls of Fortuna rice from Texas. Three times natural size.

may dry up before the crop is fully mature, and the yield and quality of the rice may be affected seriously.

[7] *Helminthosporium oryzae* van Breda de Haan.

The brown spot fungus also causes the condition known as rotten neck, similar to that caused by the blast fungus (fig. 5) which causes the upper part of the affected stem and branches of the head to break over. The tissues of such infected parts turn brown, shrivel, and die, and the weight of the heads or parts of heads breaks the stalks at such weakened points, allowing the heads or parts of the heads to hang down. If the "necks" or branches of the heads break before the rice is mature, the kernels are light in weight and of inferior quality.

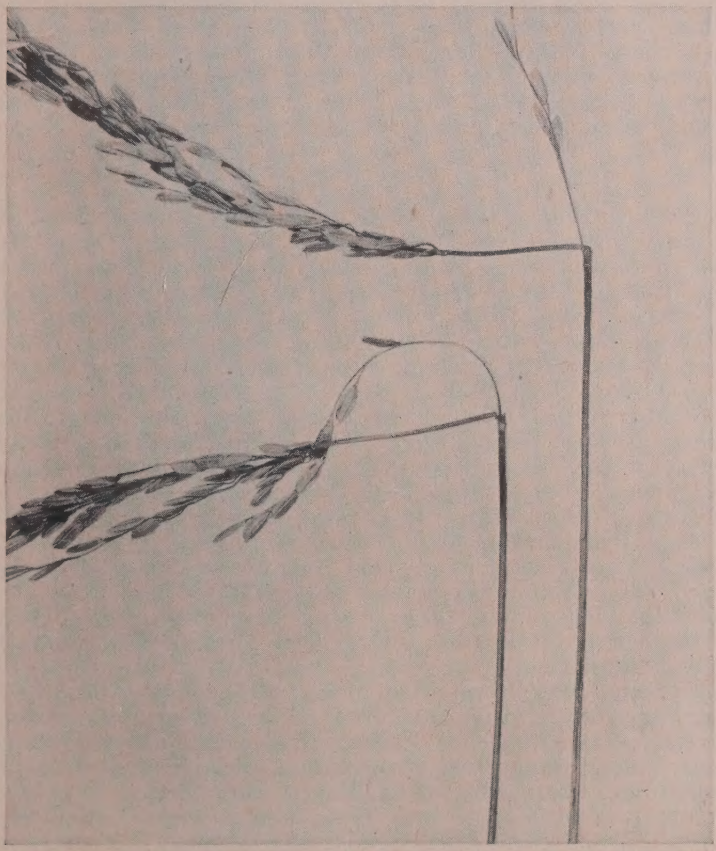

Figure 5.—Rotten neck symptoms of the blast fungus on Early Prolific rice. One-half natural size.

Spots on the hulls (glumes) when they are still green look much the same as those on the leaves, and the brown edges of the spots are still visible after maturity (fig. 4, *B*). Spots may occur on the kernel under the spots on the hulls, or they may be along the sides of the kernel. The spots that appear along the sides of the kernel usually occur when the hulls fail to interlock properly after blooming and

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thereby leave part of the kernel exposed. Entire infected kernels may be brown, or only parts of them may be discolored. The term "pecky rice" is applied to kernels that are discolored. Glume spot is considerably reduced in late-maturing rice, even though the varieties may be quite susceptible. If heading is delayed until night temperatures fall below 70° F., no infection is produced. The discoloration affects the milling quality of the rice as well as its appearance. Pecky rice may be due also to injury of the kernels by other fungi or by insects.

Seedling blight resulting from the brown spot disease may be controlled in part by treating the seed.[8] However, the brown spot fungus also is carried in the soil on plant refuse and occurs on wild grasses in or near the fields and for this reason seed treatment gives only temporary protection to the young plant. The use of resistant varieties probably is the best means of controlling this disease.

BLAST

Blast, a fungus[9] disease, has at times been serious in most of the rice-growing States, with the exception of California. Blast is the most serious disease of rice in Japan, and it occurs also in China, India, the Fiji Islands, Italy, Bulgaria, Argentina, Brazil, and the Union of Soviet Socialist Republics. This disease is characterized by the breaking over of the "necks" and branches of the heads (fig. 5), by the blighting or blasting of entire heads, and by spots on the leaves and hulls. The leaf spots tend to be long and narrow on young leaves (fig. 6) and more or less circular in outline on old leaves. The circular spots usually can be found on the leaves even after they are dead. The leaf spots caused by the blast fungus are similar in appearance to brown spot, and, in some cases, it is almost impossible to distinguish them except by microscopic examination. The joints (nodes) of the stem also may be attacked.

Infected areas on the stalk and branches of the heads are dark brown. The stalk may break over at the infected joints, or the heads or parts of heads may break over where infections occur on the neck or branches of the heads. This tendency may differ greatly with different varieties.

Rice plants may be attacked by the blast fungus while they are young, prior to irrigation, or during the period after the water has been drained from the field. Under such attacks the leaves of infected plants wither and dry, and the sheaths turn brown. Infected areas occur at the junction of leaf blade and leaf sheath. This has not been observed in the brown spot disease and may serve to differentiate the two diseases where this symptom may be found. A severe infection by this disease may reduce yields and lower the market value of the rice. Severe outbreaks of blast on newly cleared or newly broken land unquestionably result from infected wild grasses that were growing on the land before it was sown to rice.

Blast injury during early growth of the rice plants may be reduced by submergence of the land as soon as the leaf spots become evident. The breaking of the stalk and rachis may best be controlled by develop-

[8] See footnote 4, p. 2.

[9] *Piricularia oryzae* Br. & Cav.

Figure 6.—Leaf spots on young rice leaves artificially inoculated with blast fungus in the greenhouse. Natural size.

ing varieties that will not tend to break over even though infected. The excessive use of fertilizers of high nitrogen content should be avoided in fields in which blast has been found and on land that has not been recently cropped to rice. Resistant varieties, such as Zenith, Arkansas Fortuna, Bluebonnet, or Nira, should be planted on new land in Arkansas as a first crop or in the other areas in which blast is known to occur. Second-year crops are rarely severely affected.

NARROW BROWN LEAF SPOT

Narrow brown leaf spot [10] was the most widespread leaf spot on rice in Arkansas, Louisiana, and Texas from 1934 to 1938. This disease occurs in Brazil, Argentina, Japan, China, Indonesia (Dutch East Indies), Burma, the Dominican Republic, and Puerto Rico. The spots, which occur on the leaves, are long and narrow (fig. 7, *A*) and, therefore, are easily distinguished from those produced by other fungi. Usually the narrow brown spots do not appear on plants in

[10] *Cercospora oryzae* Miyake.

great abundance in the field until late August and September. The bleached dead center, common to other leaf spots of rice, occurs only in very susceptible varieties. Injury to affected plants is confined mainly to the reduction of leaf area. Marked differences in varietal susceptibility indicate that this disease may be controlled by the selection and use of resistant varieties.

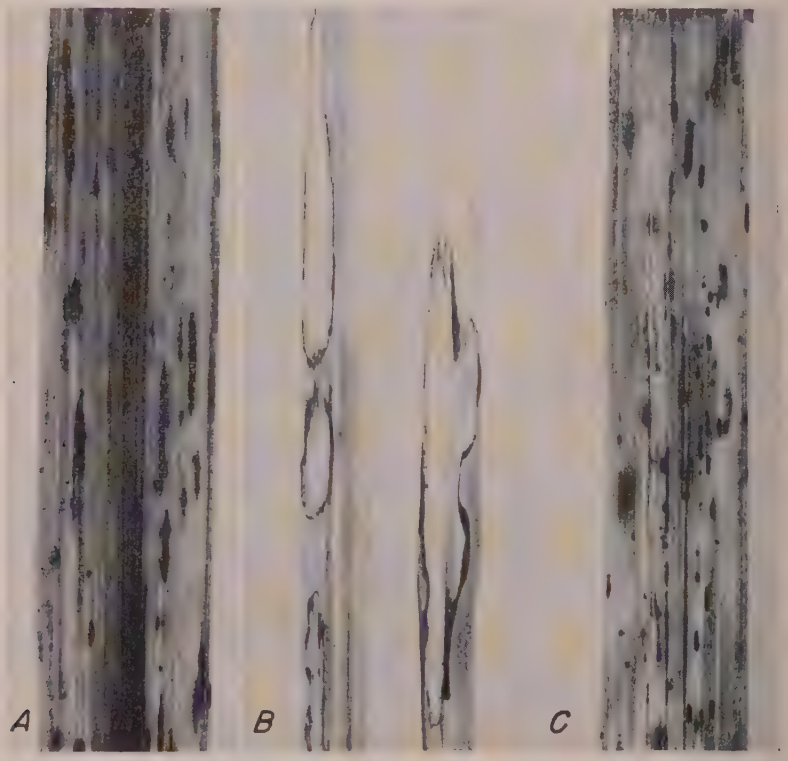

Figure 7.—A, Narrow brown leaf spot of rice. Twice natural size. *B,* Brown-bordered spot of rice leaves. Natural size. *C,* Leaf smut of rice. Twice natural size.

BROWN-BORDERED LEAF SPOT

Brown-bordered leaf spot is a fungus [11] disease that occurs on rice in Arkansas, Louisiana, and Texas. It occurs also on rice in Japan and the Philippines. The spots are light brown at first and their centers become lighter as they enlarge (fig. 7, *B*) and extend from the midrib to the margin of the leaf. The fungus bodies (pycnidia) in which the spores are produced, visible only under a magnifying lens, are light brown. Most commercial varieties of rice are rather resistant to this leaf spot, and it has never been found to cause any great damage.

[11] *Phyllosticta glumarum* (Ell. & Tr.) Miyake.

LEAF SMUT

A leaf smut of rice, caused by a fungus,[12] occurs in Arkansas, Louisiana, and Texas. It is also known to occur in Argentina, the Philippines, and Japan. This smut is found in July, August, and September on the leaves, leaf sheaths, and occasionally on the upper part of the stalk, where it shows as small black spots. These spots (sori) contain the black spores of the smut fungus. The spots at first are slightly raised, but later the leaf tissues over the sori break open lengthwise and allow the spores to escape. Smut spots on the leaves are shown in figure 7, *C*. In this disease, as in the narrow brown leaf spot, the injury to the plant consists in reducing the leaf area.

Varieties differ in susceptibility to leaf smut. Therefore, the use of the more resistant types will help to control the disease.

BORDERED SHEATH SPOT

Bordered sheath spot is a fungus [13] disease of rice that occurs rather commonly in Louisiana and Texas and to some extent in Arkansas and California. The disease appears chiefly on the sheaths above the water line and also may occur on the leaves. The spots are more or

Figure 8.—Bordered sheath spot of rice. Three times natural size.

less irregular in outline. Their centers, particularly between the veins, are cream-colored, and their outer borders are rather broad and dark reddish brown. The inner edges of the borders are usually jagged (fig. 8).

[12] *Entyloma oryzae* H. & P. Sydow.
[13] *Rhizoctonia oryzae* Ryker & Gooch, *R. solani* Kühn, and *R. zeae* Voorhees.

The discoloration of the sheaths produced by this disease is not so intense as that caused by the other sheath diseases. The disease apparently is usually of minor importance on rice. The fungus is known to attack sugarcane and Bermuda grass as well as rice.

Various diseases of rice caused by the genus *Rhizoctonia* have been reported from India, China, Japan, and the Philippines.

SHEATH ROTS

BLACK SHEATH ROT

Black sheath rot is a fungus [14] disease originally found on rice in Arkansas. Later it was found also in Louisiana and Texas. Considerable losses in the vicinity of Monticello, Ark., and Hockley, Tex., have been sustained from the attack of this fungus. It appears to be much more active on certain sandy soil types than on the heavier soils. In the earlier stages of the disease it is difficult to distinguish

Figure 9.—Black sheath rot of Blue Rose rice. Natural size.

[14] *Ophiobolus oryzinus* Sacc.

from stem rot because blackening of the sheaths occurs in both. The disease usually appears on rice in late July and in August. The tissues of the sheaths attacked by the fungus soon begin to rot, however, so that in severe cases the leaf sheaths are entirely rotted away at the water line, but the stems are rarely attacked as in stem rot. The fungus overwinters on rice stubble and also on the sheaths of the cattail.[15] Leaf sheaths of rice plants grown in the greenhouse, with various degrees of rotting, are shown in figure 9.

REDDISH-BROWN SHEATH ROT

Reddish-brown sheath rot is a fungus[16] disease, somewhat similar to the black sheath rot that occurs on rice in the South, but it is not very common. Late in the season the lower leaf sheaths become reddish brown and somewhat rotten, although rotting is not so severe as in the black sheath rot. Irregular, dark, seedlike fungus bodies are embedded in the sheaths and characteristic spores are found on the surface of the spots. It is not a serious disease on rice.

STEM ROT

Stem rot is one of the more important diseases of rice. It is caused by either of two species of fungi,[17] both of which may be found on the same plant. The disease occurs in Arkansas, Louisiana, Texas, and California, but it is more widespread and causes greatest losses in Arkansas and Louisiana. Stem rot has been reported from Italy, Bulgaria, Portugal, India, Cochinchina, Ceylon, Japan, and the Philippine Islands.

The earliest signs of the disease may be seen late in July or early in August, when small, black, discolored areas appear on the leaf sheaths at the surface of the water or slightly above. When the spots on the lower outer leaf sheaths enlarge, the inner sheaths also are invaded and discolored. When the infection reaches the stalk, numerous small, shiny, black, appressed bodies are produced on it by the fungus. Dark masses of fungus threads then develop on the stalk, and longitudinal brown to black streaks appear in the stalk above and below these masses. Various stages of development are shown in figure 10. Soon the fungus threads may be found in the interior of the stalk, as a cottony white mass, and by the time the rice is nearly mature, numerous small black seedlike fungus bodies (sclerotia) may be found in the sheaths and stalks. It is at this stage that the stalks break over and the plants lodge (see cover-page illustration). Plants infected at an early stage of development produce only lightweight heads. Many of the larger heads on lodged plants are lost when the rice is harvested because they hang so near the ground that they cannot be saved. It has been shown that the fungus remains alive in the soil for 6 years.

The fungus lives through the winter as seedlike fungus bodies (sclerotia) in stubble and soil, and these bodies floating on the water produce the primary infection on the sheaths of plants the following

[15] *Typha latifolia* L.

[16] *Helicoceras oryzae* Linder & Tullis.

[17] *Leptosphaeria salvinii* Catt. and *Helminthosporium sigmoideum irregulare* Cralley & Tullis.

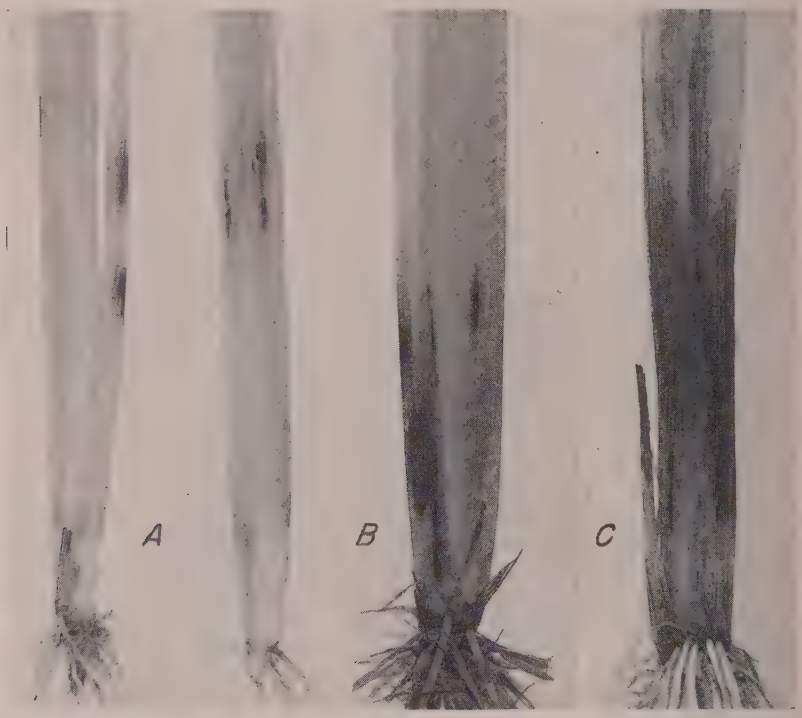

Figure 10.—Stem rot on outer sheaths of Blue Rose rice plants, showing various stages of development: *A*, Early stage; *B* and *C*, progressively later stages, showing severe rotting in C. Natural size. (Courtesy of Arkansas Agricultural Experimental Station.)

summer. Primary infection may also be produced from the fungus living over on barnyard grass [18] and on southern wildrice [19] growing in and near fields and in irrigation ditches. Southern wildrice is found rather commonly, especially in Louisiana. Secondary infection by spores (conidia) produced on the sheaths occurs after the fungus has become established on the rice plant. Sclerotia that will germinate have been recovered from infested soil as much as 3 years after the land was last cropped to rice.

The most satisfactory method of control is to drain the water from infected fields before the infections have reached the rice stalk. Enough water should be added from time to time thereafter to keep the soil saturated but not submerged. Such treatment results in a slight reduction in yield. However, in badly infected fields such treatment may result in higher yield, because lodging can thus be prevented and all the rice can be harvested. No highly resistant varieties of commercial value are available in the South.

[18] *Echinochloa crusgalli* (L.) Beauv.
[19] *Zizaniopsis miliacea* (Michx.) Doell & Aschers.

KERNEL DISEASES

KERNEL SPOTS

A number of types of kernel spots are found on rice. One type has already been referred to under the brown spot disease (p. 6). Another, which is known as "black kernel," is caused by a fungus [20] that frequently blackens the entire kernel inside and out. Small, slightly raised, seedlike fungus bodies dot the surface of the kernels. In other cases the affected kernels show only surface discoloration. Other fungi [21] [22] produce pink or red color in the grain.

Rice kernels that are severely infected with any of these kernel spot fungi usually germinate poorly and rarely produce good plants. Kernel spots caused by some of these fungi have been reported from Indochina and Japan.

Many of the diseased kernels are chalky in texture and, therefore, are broken when the hulls are removed or later in the milling process; thus, the yield of head rice may be appreciably reduced. When the diseased kernels are not chalky but discolored throughout, the discoloration cannot be removed in milling.

Another type of kernel spot is caused by the rice stinkbug and another small sucking insect,[23] which puncture the developing kernels with their beaks, feed on the contents, and apparently facilitate the entrance of spot fungi. This kernel spot affects the milling quality in much the same manner as those referred to previously. The presence of any of these types of discolored kernels in milled rice reduces the grade.

KERNEL SMUT

Kernel smut of rice, caused by a fungus,[24] occurs occasionally in Arkansas, Louisiana, and Texas. This disease occurs also in Japan, China, Indonesia (Dutch East Indies), and the Philippine Islands. It reduces the yield and in some cases damages the quality materially because of the black or gray color of the milled rice. This discoloration is caused by the spores of the fungus that are liberated when the rice is milled. Affected kernels differ in the degree to which they are attacked. In the most severe cases the entire starchy part of the kernel (endosperm) becomes a black mass of spores. In other cases a part of the kernel may be normal. The smutted part is nearly always at the germ end of the kernel. Severely smutted kernels are light in weight and float in water. The partly smutted kernels, however, sink in water as do the normal kernels. It is, therefore, not possible to make a complete separation by flotation in water.

The smutted kernels are not noticeable until the rice is mature. Usually not more than two to six smutted kernels are found on a head. Little if any swelling of the kernel is caused by the smut, and the most conspicuous symptom is the dark discoloration on the hulls of mature seeds caused by the black smut spores showing through the hull on

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[20] *Curvularia lunata* (Wakker) Boedijn.
[21] *Trichoconis caudata* (Ap. & Str.) Clem.
[22] *Monascus purpureus* Went.
[23] *Solubea pugnax* Fab. and *Paromius longulus* Dall., respectively.
[24] *Neovossia horrida* (Tak.) Padwick & Azmutullah Khan.

the outside. The embryo (germ) is never smutted and will germinate even when the entire endosperm is reduced to a mass of smut spores.

Natural conditions in the field apparently check the disease. The commercial varieties now grown appear to differ in susceptibility to kernel smut. Usually the disease is of minor importance.

STRAIGHTHEAD

Frequently, vigorous, dark-green, normal-appearing rice plants fail to set seed in many of the flowers. As a result, the heads remain erect (fig. 11) instead of turning down as when they fill normally. This condition, known as straighthead, is most prevalent on new land and on land that has not been cropped to rice for several years, and on which a heavy growth of weeds and grass has been plowed under.

Figure 11.—Straighthead of rice (right) compared with normal (left).

Areas so affected produce little or no grain and although this condition is not frequently encountered, it is a source of considerable loss when it occurs. In fields where this disease does strike, large areas are often so seriously affected that the yield of grain is not sufficient to justify harvesting and threshing.

Land on which straighthead is likely to occur should be drained at least once and allowed to dry until the surface cracks before the rice is in the boot. It is very important that the soil become thoroughly dry on the surface for this treatment to be effective.

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